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(71) Applicant: MABUCHI MOTOR KABUSHIKI KAISHA
Matsudo-shi, Chiba-ken (JP)

(72) Inventors:
- Matsushita, Ikuo
Matsudo-shi, Chiba-ken (JP)
- Itou, Fumiyoshi
Matsudo-shi, Chiba-ken (JP)
- Onishi, Megumu
Matsudo-shi, Chiba-ken (JP)

(74) Representative: Hitchcock, Esmond Antony
Lloyd Wise, Tregear & Co.,
Commonwealth House,
1-19 New Oxford Street
London WC1A 1LW (GB)

(54) Miniature motor

(57) A miniature electric motor comprises a two-pole stator (1), and a rotor having at least three salient poles each having a core (8) with flanges (11) extending toward both sides thereof. The rotor is adapted to apparently form a two-pole construction by cutting off at least the tip of a flange (11) on either side on a part or all the salient rotor pole cores, thereby limiting the spontaneous-stop angular positions of the rotor to tow. One insulating spacer is provided between a plurality of commutator segments of the commutator to come in contact with one of two brushes when the rotor is at a spontaneous-stop angular position.

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Description

This invention relates to a miniature motor with provision for self-inactivation. It relates particularly to the provision of this feature in motors of the type which include a rotor with three or more salient poles and a commutator with three or more grooves.

Known miniature electric motors using a rotor with three or more salient poles and a commutator with three or more grooves have no self-inactivating function. For this reason, when excess load is applied to the motor or rotation is forcibly discontinued, the motor tends to burn out due to overheating because excess current is kept flowing. Even if stopped temporarily, and the motor happens to restart suddenly immediately after the load is removed, the same problem can arise. As a result, the miniature motor, when used in a model aeroplane, for example, tends to burn out if the model falls to the ground, or the plane can go out of control due to the sudden restart of the motor. In another example, an electric fan in which a miniature motor having no self-inactivating function is incorporated can be very dangerous if a child happens to put his finger into the fan guard.

To equip a miniature motor with a self-inactivating function, it should be of such a construction that current supply is interrupted when the rotor of the motor is at a spontaneous-stop angular position. With a miniature motor having two salient rotor poles, where it is relatively easy to limit the spontaneous-stop angular position, current supply can be easily interrupted at the limited stop position.

The term "self-inactivating function" used herein means a function that prevents current from flowing in the motor which is forcibly stopped while the power is on, by means of a specially designed insulating spacer on the commutator. The motor having the self-inactivating function requires an external force (by hand, for example) to be started again.

The term "spontaneous stop" used herein means that after the power is turned off, the motor keeps running for a while due to inertial force and eventually comes to a halt.

The present invention seeks to adopt a miniature motor using a rotor with three or more salient poles to prevent it from being burnt out or restarted suddenly after a stop by providing the motor with a self-inactivating function which interrupts current supply at rotor spontaneous-stop angular positions. It seeks to achieve this while maintaining motor torque by minimizing the non-conduction angle at which no current is supplied to the motor rotor.

A miniature motor according to this invention has such a construction that the core of the rotor having three or more salient poles as a whole acts as an apparent two-pole construction. This transformation is preferably accomplished by cutting at least a tip of a flange on one side for a part or all or the rotor core to limit the number of rotor spontaneous-stop angular positions to two. Only one insulating spacer is provided between plurality of commutator segments in such a manner that the insulating spacer is disposed so as to come in contact with any of two brushes when the rotor is at a spontaneous-stop angular position.

The invention can enable a motor having a rotor with three or more salient poles in an apparent two-pole construction to achieve the effect of "high torque and high motor efficiency" intrinsic to motors having three or more rotor poles by limiting the number of spontaneous-stop angular position of the rotor to two. With the arrangement disclosed herein, current can be positively interrupted when excess load is applied to the motor, causing motor rotation to forcibly stop. The motor, once stopped in this manner, can be prevented from being suddenly restarted, or from running out of control, and can be restarted merely by giving an inertial force externally. Thus, the motor requires no switches. This effectively reduces the weight of the motor, simplifies circuitry, and is also economical. Furthermore, this type of motor with a self-inactivating function is safe when applied to model aeroplanes and electric fans for example.

A miniature motor according to a preferred embodiment of this invention has three salient rotor poles, with one pole core having bilaterally symmetrical flanges, and the remaining two pole cores having two flanges, one of which on the side of the pole core having the bilaterally symmetrical flanges has been cut off at least at the tip thereof. With this construction, the number of spontaneous-stop angular positions of the rotor are limited to two, as with the motor having a two-pole rotor, and current is not allowed to flow at these limited spontaneous-stop positions.

The miniature motor of the above embodiment can exhibit large cogging because at least the tip of the aforementioned flange on the side of the pole core having bilaterally symmetrical flanges is cut off with a predetermined angle left between the cutting direction and the radial direction from the central axis so that as much core area as possible can be left. The windings of the miniature motor of this invention can be retained on the core even when a large portion of the core tip is cut off to ensure large cogging by preserving uncut the outermost laminate sheets on both sides of the laminated pole core in the laminating direction.

In another embodiment of the invention the motor has four salient rotor poles, with at least the tips of the flanges of all the four poles being cut off alternately on the right or left side. This embodiment can also interrupt current supply at any of the stop positions with only one insulating spacer.

In motors of the invention the non-conduction angle at which no current is supplied to the rotor can be varied by adjusting the width or height of the insulating spacer. With this, so can the force required for restart be adjusted.

The invention, and a known motor construction, will now be described by way of example and with reference

to the accompanying drawings wherein:

Figure 1 is a diagram illustrating the overall construction of a miniature motor embodying this invention, with the upper half shown in cross section;
Figure 2 is an axial cross-section of the commutator and magnetic pole core of the miniature motor shown in Figure 1;
Figure 3 is a plan view of the rotor of the miniature motor shown in Figure 1;
Figure 4 is an axial cross-section of the commutator and poles of the rotor shown in Figure 3;
Figure 5 is an exploded perspective view of a commutator for a miniature motor having three salient rotor poles;
Figure 6 is a diagram illustrating the stop positions of a miniature motor using three salient rotor poles having a core configuration according to this invention;
Figure 7 is a diagram illustrating how the force required for restart can be adjusted by adjusting the width or height of the insulating spacer;
Figure 8 is a diagram illustrating another example of how to cut off the tip of a salient rotor pole core flange;
Figure 9 is a diagram illustrating still another example of how to cut off the tip of a salient rotor pole core flange;
Figure 10 shows a miniature motor embodying this invention, having four salient rotor poles;
Figure 11 shows the rotor of a conventional type of miniature motor using two salient rotor poles;
Figure 12 is a cross-section taken substantially along line I-I in Figure 11;
Figure 13 is an exploded, enlarged perspective view of the commutator of the conventional type of rotor shown in Figure 11; and
Figure 14 illustrates the stop positions of a conventional type miniature motor having a three-pole rotor.

A conventional two-pole motor will first be described with reference to Figures 11 to 13. In Figures 11 and 12, numeral 7 refers to a rotor shaft, 8 to a salient rotor pole core, 10 to a commutator, 11 to a flange of the pole core 8, and 16 to a pole winding, respectively. Since this miniature motor has a two-pole stator (not shown) consisting of two magnets, there are only two angular positions at which the motor stops spontaneously due to the influence of cogging; namely, an angular position at which one salient rotor pole face the N pole of the stator while the other salient rotor pole faces the S pole, and an angular position, rotated 180° from the aforementioned angular position, at which one salient rotor pole faces the S pole of the stator while the other salient rotor pole faces the N pole. Conventional miniature motors having a self-inactivating function have such a construction that current supply is interrupted when the rotor is at any of the spontaneous-stop angular position.

Figure 13 is an exploded perspective view of a commutator in the rotor shown in Figure 11. Two commutator segments 12 are provided on the outer peripheral surface of a commutator cylinder 14 made of an insulating resin, with two insulating spacers 15, which is integrally formed with the commutator cylinder 14, provided between the two commutator segments 12 to separate and insulate the commutator segments. Numeral 13 refers to a commutator support ring. Two brushes are disposed in such a positional relationship that the brushes are each on two insulating spacers 15 when the motor rotor is at any of the spontaneous-stop angular positions. With this arrangement, the self-inactivating function of a miniature motor having a two-pole rotor can be accomplished as current supply is interrupted at any of the positions where the rotor is stopped, and no sudden restart is caused.

To obtain a larger torque without increasing the size of the motor, the motor is required to have three or more salient rotor poles. It has been practically impossible to achieve a self-inactivating function with the conventional motors having three or more rotor poles. Since the motor commutator is originally used to feed current to rotor windings, it is not desirable to increase the torque of the motor by providing a large number of insulating spacers on the commutator surface to increase the non-conduction angle at which no current is supplied to the rotor. Motors with three or more rotor poles, on the other hand, involve multiple spontaneous-stop angular positions. In a three-pole motor, for example, in which the motor stops at positions of 360°/6, it is practically impossible to interrupt current supply at all the stop positions to maintain motor torque.

Figure 14 illustrates stop positions in a conventional type of miniature motor having a three-pole rotor. At position (a) of the spontaneous-stop angle of 0° at the left of Figure 14, a first salient rotor pole core faces the S pole of the stator. This represents a spontaneous-stop angular position. At a position (b), rotated 60° from the original position, a second salient rotor pole faces the N pole of the stator, where the motor stops spontaneously. Similarly, there are spontaneous-stop angular positions at every turn by 60°. Since the 360° position (g) is the same as the 0° position, there are a total of six spontaneous-stop angular positions. To achieve the self-inactivating function, insulating spacers must be inserted in all the three gaps between the three commutator segments to interrupt current supply at all the six spontaneous-stop angular positions. As described above, however, it is practically impossible to achieve this in terms of motor torque. Even when only one insulating spacer is inserted to interrupt current supply at the spontaneous-stop angular position (a) of 0° to prevent the motor from restarting suddenly, current supply cannot be interrupted at the next position (b), rotated 60°, or at the position (c), etc. The terms "Can be started" and "Cannot be started in Figure 14 mean this state.

A miniature motor having three salient rotor poles embodying this invention is shown in Figure 1. The motor has magnets 1 constituting two-pole stator poles, mounted in a housing 2. A commutator 10 and a rotor core 8 having flanges 11 are mounted on a shaft 7. The shaft 7 is mounted in bearings 3 for rotation in the housing 2.

The stator of the miniature motor shown in Figures 1 to 4 is of a two-pole construction formed by the magnets, while the rotor 8 thereof is of a salient three-pole construction having windings 16. This miniature motor, which rotates normally by feeding current through the commutator, is characterised by the construction of the core flange 11 of the salient rotor pole, which will be described later, and the construction of the commutator. That is, whereas the rotor of this miniature motor is actually of a salient three-pole type, the core 8 has such a construction as to apparently form a two-pole configuration as a whole by cutting off at least a tip of the flange 11 on one side for two of the three salient rotor poles. With this arrangement, the number of spontaneous-stop angular positions are limited to two, as with the aforementioned motor having a two-pole rotor, and current flow is adapted to be interrupted at these limited rotor stop positions.

The commutator of Figure 5 has three commutator segments 12 each having the same construction, which are held in place by a commutator support ring 13, separated by an insulating spacer 15. The insulating spacer 15, the only one of which is provided for the commutator, has a predetermined width in the circumferential direction, and can be formed integrally with the commutator cylinder made of an insulating resin. Though the detailed operation will be described later, any one of the two brushes is adapted to be in such a positional relationship as to come in contact with the insulating spacer 15 at any one of the rotor spontaneous-stop positions. Current is therefore interrupted at the rotor spontaneous-stop positions. Although the miniature motor of this invention has an insulating spacer for interrupting current supply on the outer peripheral surface of the commutator, motor rotation can be maintained by inertial force during motor rotation under the rated load even when the brush happens to ride over the insulating spacer. If the brush fails to ride over the insulating spacer due to the decreased inertial force resulting from a drop in motor rotation under an overload condition, current supply to the motor is interrupted, causing the motor to stop. The motor remains stopped until restarted by applying an external force.

As shown in Figure 6, one of the three salient rotor poles or this invention has bilaterally symmetrical core flanges, as in the prior art poles described earlier, referring to Figure 11 and 12, while each of the remaining two poles has a flange on the side of the bilaterally symmetrical pole which has been cut off at least the tip thereof. With this arrangement,the pole ores having flanges with cut-off tips are bilaterally asymmetrical, but the salient rotor poles as a whole are bilaterally symmetrical with respect to a line passing through the centre of the bilaterally symmetrical pole, and apparently forms a two-pole construction, with the bilaterally symmetrical pole as one pole and the remaining two poles with cut-off flange tips collectively as the other pole.

This type of miniature motor stops due to the effect of cogging at the spontaneous-stop position (a) of 0° as shown at the left of Figure 6. In this state, the bilaterally symmetrical pole of the three salient rotor poles faces the S pole of the stator, while the remaining two salient rotor poles collectively face the N pole of the stator. At this spontaneous-stop position (a), the positive-side brush comes in contact with a commutator segment, as shown in the Figure, whereas the other negative-side brush rests on the insulating spacer integrally formed with the commutator cylinder. In this state, the current path from the positive-side brush to the negative-side brush via the commutator segments and the windings is cut off, preventing the current from flowing in the path. Thus, the motor is prevented from starting suddenly. The motor that remains stopped can be restarted by applying an inertial force externally (by hand, for example).

The motor stops next at the spontaneous-stop position (b) of 180° where the bilaterally symmetrical pole faces the other N pole of the stator, and the remaining two salient rotor poles face the S pole of the stator. At this stop position (b), the positive-side brush rests on the insulating spacer, preventing current from flowing, and thereby preventing the motor from starting suddenly. The motor stops next at the spontaneous-stop position (c) of 360° which is the same as the stop position of 0° and 180° where either of the brushes comes in contact with the insulating spacer, preventing current from flowing.

Figure 7 shows how the force required for restart can be adjusted by changing the width or height of the insulating spacer. The angle at which the brush comes in contact with the insulating spacer, preventing current from flowing, can be adjusted by changing the circumferential width of the insulating spacer. To prevent the motor from starting suddenly, it is necessary to increase the external force required for restart. But a too large non-conduction angle would shorten the conduction time at which current is supplied to the rotor, leading to decreased torque. The force required for restart must therefore be adjusted appropriately in accordance with specific applications of the miniature motor.

Figure 7 shows the state where the positive-side brush comes in contact with the insulating spacer 15; Figure 7A showing the surface of the insulating spacer made flush with the outer peripheral surface of the commutator, and Figure 7B showing the surface of the insulating spacer raised from the outer peripheral surface of the commutator. The non-conduction angle can be adjusted not only by changing the width of the insulating spacer but also by changing the height thereof. In either of the Figures 7A and 7B as the rotor rotates counter-

clockwise, the positive-side brush begins coming in contact with the insulating spacer at the rotor position shown at the left, breaking the contact with the commutator. The Figure also shows that this state is kept until the rotor rotates to the angular position shown at the right. figure 7 also shows an example that the non-conduction angle of the rotor set at 27.47° by changing the width of the insulating spacer can be set to 85.73° by changing the height of the insulating spacer without changing the width thereof.

Figure 8 shows another example of the core flange of the salient rotor pole the tip of which was cut off. As shown the tip of the core flange was cut off at a predetermined angle θ (preferably, 48° - 88°) in the radial direction (that is, in the outward direction from the centre axis). By doing this, large cogging can be obtained while leaving as much core as possible uncut.

Figure 9 shows still another example of the salient rotor pole the tip of which was cut off. In the example, the tip of the core flange was cut off, with the outermost laminate sheets on both sides left uncut. By doing this, the windings are prevented from coming out of the core even when the tip of the core is cut off to a large extent to ensure large cogging.

Figure 10 shows an embodiment of the invention having four salient rotor poles. The salient rotor pole core of the motor is such that at least the tip of one of the two flanges extending toward both sides of the core is cut off alternately in such a manner that the uncut flange of the adjoining poles face each other, with the cut-off flanges of the adjoining poles facing each other, so that the pole core forms a two-pole configuration. With this miniature motor having four salient rotor poles, where there are only two spontaneous-stop positions; that is, the position shown in the Figure, and a position turned 180° from that position, current can be interrupted at any stop position with one insulating spacer, and the windings can be easily wound because the tips of the flanges were cut off.

Claims

1. A miniature motor comprising a two-pole stator; a rotor with at least three salient poles each having a core with a flange extending on either side and a winding; and a commutator and brushes,
   CHARACTERISED IN THAT
   the rotor is an apparent two-pole construction with only two spontaneous-stop positions, an insulating spacer being provided between commutator segments of the commutator to make contact with any of two brushes when the rotor is at a spontaneous-stop position.

2. A miniature motor according to Claim 1 wherein the rotor is of apparent two-pole construction by cutting at least a part of the rotor pole cores to limit the number of spontaneous-stop positions to two.

3. A miniature motor according to Claim 2 wherein the rotor has three salient poles, one pole core having bilaterally symmetrical flanges and the remaining two pole cores each having two flanges, of which one on the side of said one pole core has a portion cut off at least the tip thereof.

4. A miniature motor according to Claim 3 wherein at least the tip portion of said flange is cut at a predetermined angle to the radius from the rotor axis.

5. A miniature motor according to Claim 3 wherein the rotor core is laminated, and wherein at least the tip portion of said flange is cut with the outermost laminate sheets on both sides of laminated pole cores left uncut.

6. A miniature motor according to Claim 2 wherein the rotor has four salient rotor poles; at least the tips of flanges on all four poles being cut off alternately.

7. A miniature motor according to any preceding Claim wherein the non-conduction angle is determined by the dimensions of the insulating spacer.

FIG. 1

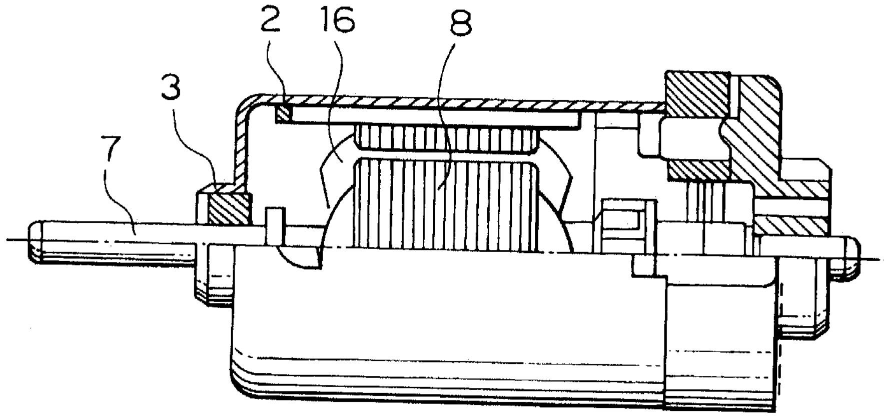


FIG. 2

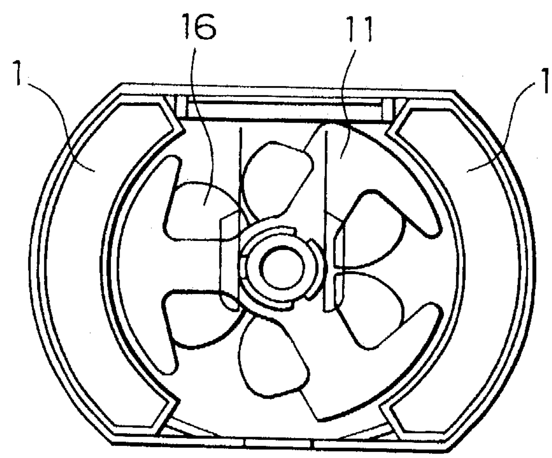


FIG. 3

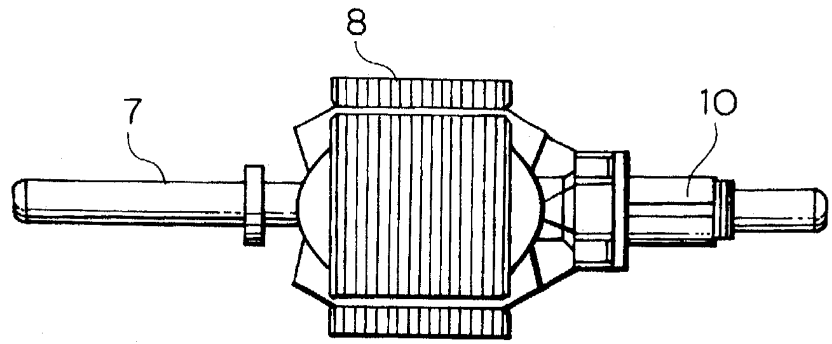


FIG. 4

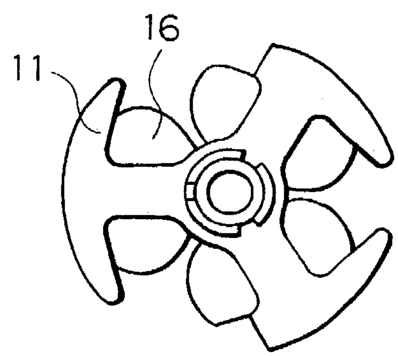


FIG. 5

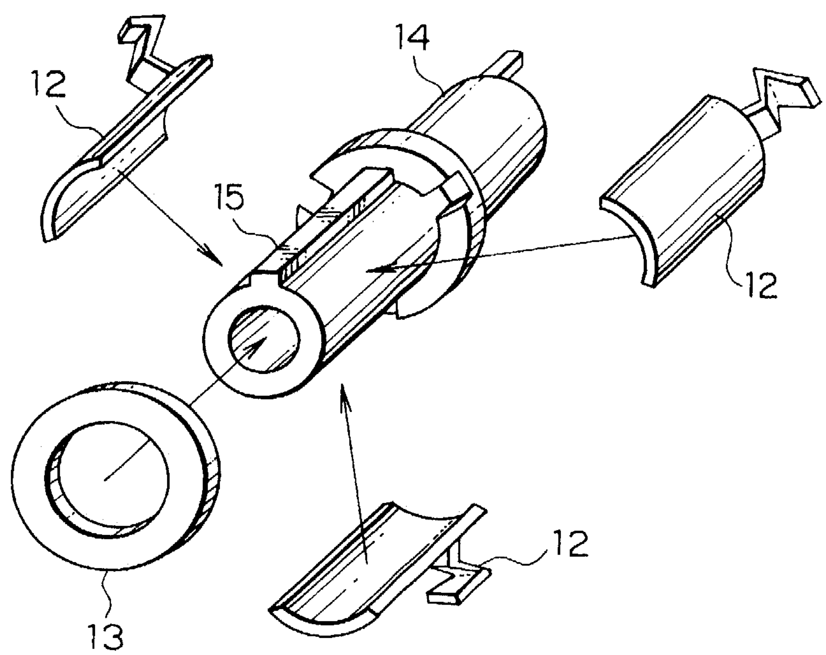


FIG. 6

(a) 0°

(b) 180°

(c) 360°

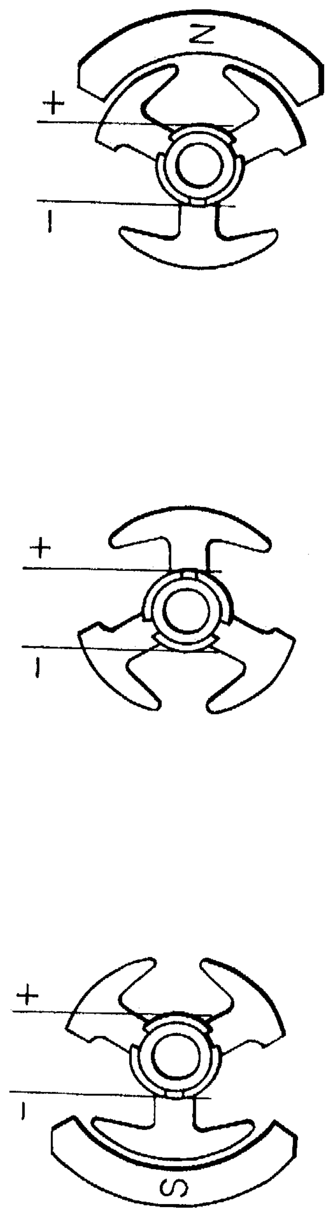


FIG. 7A

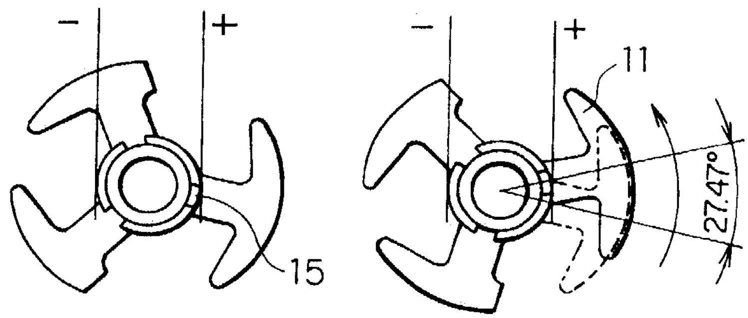


FIG. 7B

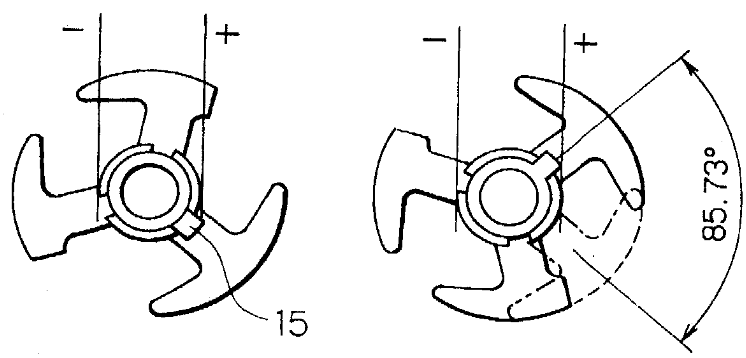


FIG. 8

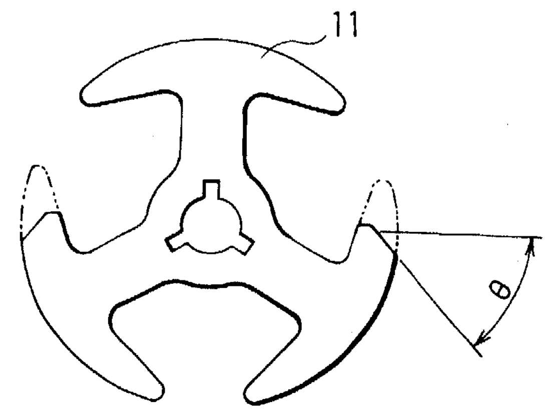


FIG. 9

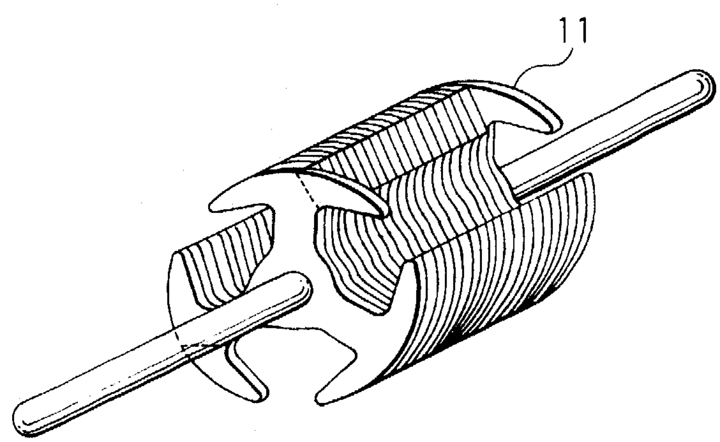


FIG. 10

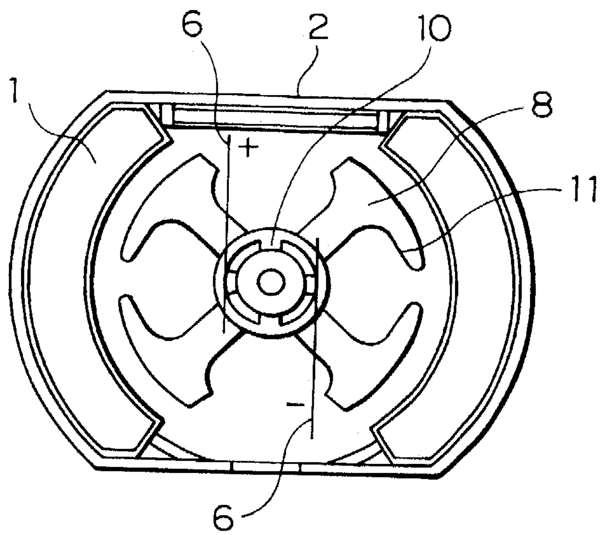


FIG. 11

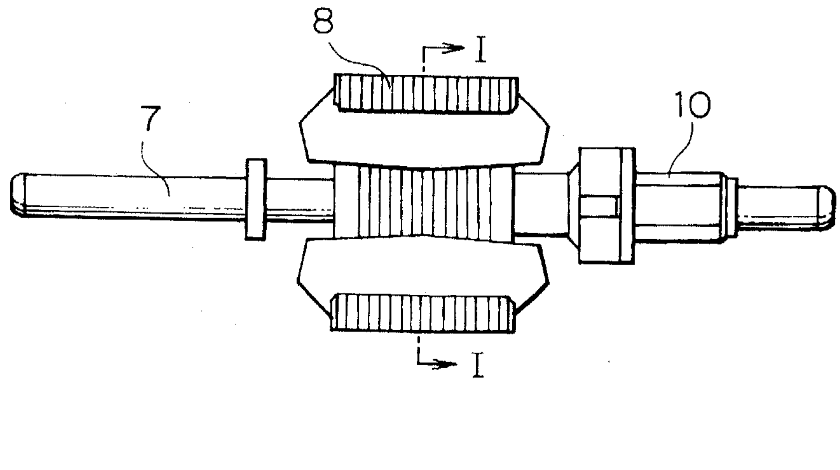


FIG. 12

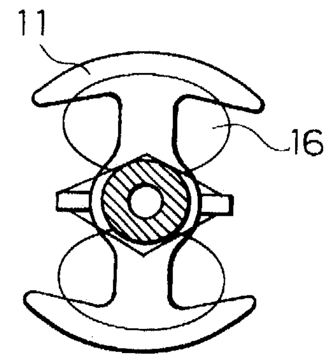


FIG. 13

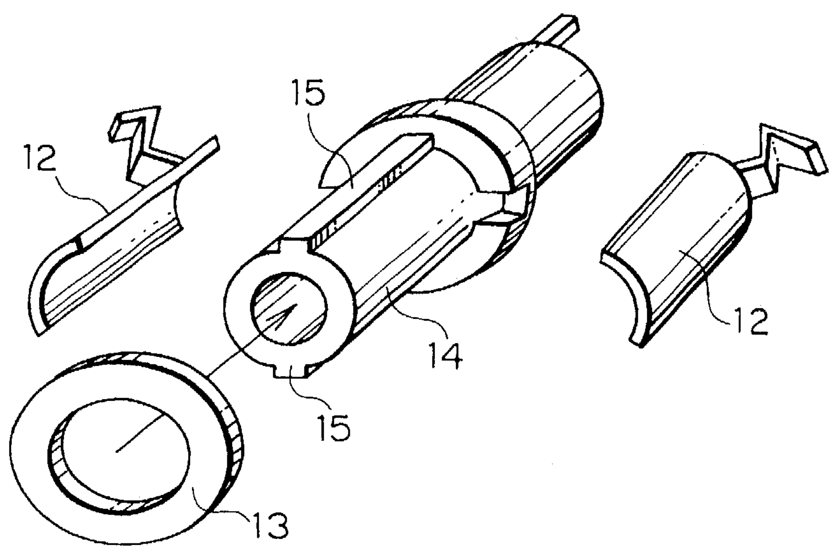
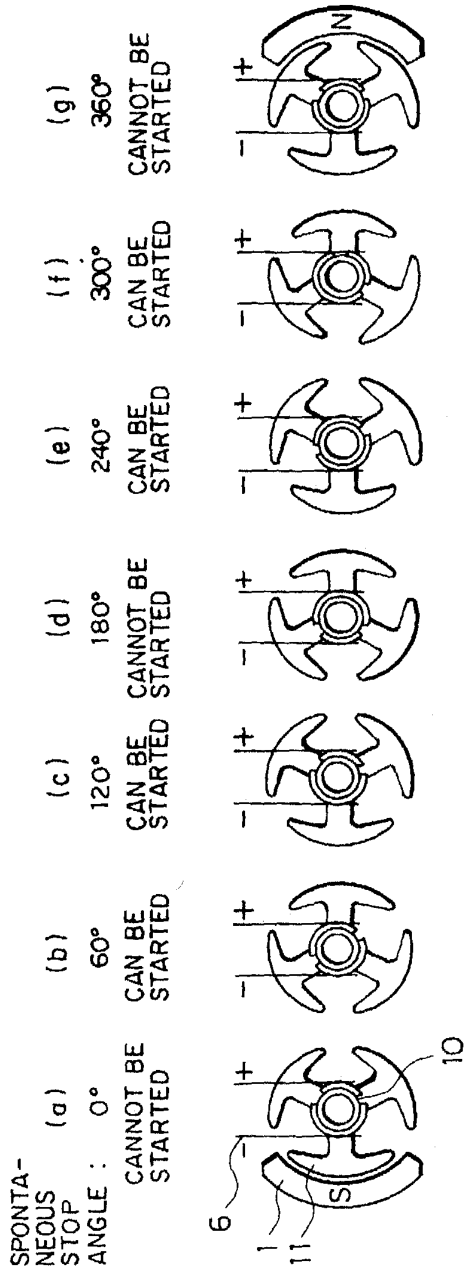


FIG. 14


SPONTA-
NEOUS
STOP
ANGLE :
(a) 0°
CANNOT BE STARTED
(b) 60°
CAN BE STARTED
(c) 120°
CAN BE STARTED
(d) 180°
CANNOT BE STARTED
(e) 240°
CAN BE STARTED
(f) 300°
CAN BE STARTED
(g) 360°
CANNOT BE STARTED
6
1
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